

Although the evidence presented in the cross-country studies argues for a weaker version of decreasing returns to capital, none of the studies suggest that such decreasing returns do not exist (even in the presence of spillover effects). Paul Romer has concluded that:

The regression evidence shows that increased investment tends to be correlated with a lower marginal product of physical capital. The precision of these estimates is not sufficient to conclude that increased investment has no effect at all on technological change, but at a minimum the estimates show that increased investment does not seem to induce enough technological change to offset completely the diminishing returns associated with increased capital accumulation.²³

Martin Baily and Charles Schultze buttress this observation by noting that between 1948 and 1968, the amount of capital per worker in the United States fell while the return to capital rose.²⁴ And the opposite has been true since 1973. This pattern of correlations is exactly what one would expect if capital had diminishing returns. Similar results are reported by Alwyn Young, who examined the postwar economic experience of Hong Kong and Singapore.²⁵ Young found that although the two economies experienced similar rates of growth during that period, the sources of growth were quite different. Growth in Hong Kong was driven both by the accumulation of labor and capital and by technical progress. In contrast, Singapore's growth was driven almost entirely by the accumulation of labor and capital, especially by investment in physical capital; technical progress played a very small role. Consequently, Singapore experienced sharply decreasing returns to capital. By Young's estimate, the real return to capital in Singapore declined from about 40 percent in the early 1960s to about 10 percent in the late 1980s.

23. Romer, "Capital, Labor, and Productivity," p. 339.

24. In this comparison, labor is measured in efficiency units, and the marginal product of capital is measured using the profit rate. For details, see M. Baily and C. Schultze, "The Productivity of Capital in a Period of Slower Growth," *Brookings Papers on Economic Activity: Microeconomics* (1990), pp. 369-419.

25. A. Young, "A Tale of Two Cities: Factor Accumulation and Technical Change in Hong Kong and Singapore," in O.J. Blanchard and S. Fischer, eds., *NBER Macroeconomics Annual: 1992* (Cambridge, Mass.: MIT Press), 1992.

DIRECT EVIDENCE OF THE EXISTENCE OF SPILLOVERS OR INCREASING RETURNS TO SCALE

Considering the crucial role that spillovers and increasing returns play in some models of endogenous growth, surprisingly little direct evidence exists to support the idea that they play a significant role in the overall economy. Proponents of endogenous growth models generally set out to explain one or two broad empirical regularities--persistent growth of per capita output or nonconvergence, for example--but have not subjected their models to rigorous empirical scrutiny. Direct evidence of spillovers would help to distinguish which class of models better describes the data. Most of the available evidence, however, is anecdotal or limited to studies conducted on the firm or industry level that do not demonstrate the significance of spillovers in the overall economy.

Paul Romer attempts to demonstrate the importance of spillovers to R&D with three examples reported in the press.²⁶ In the first, two former employees of Du Pont were convicted of extortion for threatening to reveal the process the company used to make Lycra. In the second, Intel filed suit against a former employee who had used trade secrets at a new company. The third was an investigation into the activities of a firm that allegedly stole mechanical drawings and formulas used to make blades for General Electric turbines.

These three cases are examples of a technological advance that had been designed by one firm and was at risk of spreading (without compensation to the first company) to other firms in the industry; that is, they provide evidence of spillovers. Romer also stresses that the amounts of money at stake were large: the two former Du Pont employees asked the company for \$10 million, Intel asserted that it had spent hundreds of millions of dollars developing its microprocessors, and General Electric claimed its designs were worth \$200 million.

Such anecdotal evidence may demonstrate the existence of spillovers among firms, but it does not demonstrate convincingly their significance for the overall economy. More rigorous empirical treatments also come up short. Adam Jaffee, for example, found that the productivity of a firm's investment in research and development is enhanced by the R&D spending of other firms

26. P.M. Romer, "Are Nonconvexities Important for Understanding Growth?" *American Economic Review*, vol. 80, no. 2 (May 1990). For more examples of spillovers to research and development at the industry and firm level, see N. Rosenberg, *Inside the Black Box: Technology and Economics* (Cambridge: Cambridge University Press, 1982).

in the same industry.²⁷ He notes, however, that his evidence is largely circumstantial and that factors other than spillovers may play a role. In another study, Ricardo Caballero and Jaffee attempt to measure spillovers using rates at which patents were cited.²⁸ However, as they point out, the link between the model's theoretical constructs and the data used to estimate them is too weak to support any strong conclusions about the significance of spillovers for the overall economy.

The literature also includes studies of spillovers associated with human capital at the firm or industry level. These studies examine the idea raised by Robert Lucas that an employee will be more productive if he or she works with other employees who have above-average skills or education. In a survey of several of these studies, Larry Katz finds that the evidence suggests such an effect but is not conclusive.²⁹ However, like evidence regarding spillovers to R&D among firms, the micro-level studies surveyed by Katz do not demonstrate the importance of spillovers for the overall economy because they do not adequately measure the magnitude of the effect.

The best data on the implications of spillovers for the overall economy come from the growth-accounting studies described in Chapter II. Using the neoclassical assumption of constant returns to scale and carefully measuring human and physical capital, growth accountants cannot entirely explain the growth in output over long periods. They attribute the residual to technological progress. Of course, that finding could be the result of violating one of the model's assumptions, mismeasuring the inputs, or technological change, but it at least suggests that spillovers affect the economy. The economywide data, however, may not vary enough to distinguish between increasing returns and technological progress.

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- 27. A.B. Jaffee, "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value," *American Economic Review*, vol. 76, no. 5 (December 1986), pp. 984-1001.
 - 28. See R.J. Caballero and A.B. Jaffee, "How High Are the Giants' Shoulders: An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth," in O.J. Blanchard and S. Fischer, eds., *NBER Macroeconomics Annual: 1993* (Cambridge, Mass.: MIT Press, 1993).
 - 29. See L.F. Katz, "Commentary: Human Capital and Economic Growth," in *Policies for Long-Run Economic Growth*, a Symposium Sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyo., August 27-29, 1992 (Kansas City, Mo.: Federal Reserve Bank of Kansas City, 1992).

INTERNATIONAL FLOWS OF LABOR AND CAPITAL

The evidence on the flows of labor and capital between countries is somewhat difficult to explain using the neoclassical model. The standard version of the model, which assumes identical economies and no imperfections in the market, implies instantaneous convergence as capital moves rapidly to equalize returns for all countries. Labor is typically assumed to be immobile. In reality, the world is marked by differences in per capita income that are too large to be explained by differences in ratios of capital to labor. In addition, capital seems to flow in the wrong direction, and workers are subject to persistent pressure to migrate from poor countries to rich countries.

Flows of Capital

The neoclassical model suggests that capital should flow from rich countries to poor countries since poor countries, with their low levels of capital per worker, should have higher rates of profit. Such capital flows would reinforce the neoclassical model's prediction that poorer countries will catch up to richer countries. However, the data seem to indicate that when capital flows, it flows either between rich countries or from poor countries to rich countries.³⁰

Martin Baily and Charles Schultze argue that, at least among developed nations, flows of long-term capital are consistent with the predictions of the neoclassical model.³¹ They point out that long-term capital flowed from Europe to the United States during the 19th century, presumably in search of opportunities for higher profits. During the 1950s, the flows were reversed; capital per worker was higher in the United States than in the war-ravaged economies of Europe, so capital flowed back to the continent. Baily and Schultze assert that, more recently, declining profit rates in Europe and Japan have spurred flows of capital into the United States.

30. Numerous studies have examined the international mobility of capital. The consensus is that capital is indeed mobile (and more mobile today than it was 20 years ago) and that it flows across international boundaries to even out nominal rates of return. For more details, see M. Feldstein and P. Bacchetta, "National Saving and International Investment," in B.D. Bernheim and J.B. Shoven, eds., *National Saving and Economic Performance* (Chicago: University of Chicago Press, 1991), and the references cited within.

31. See M.N. Baily and C.L. Schultze, "The Productivity of Capital in a Period of Slower Growth," *Brookings Papers on Economic Activity: Microeconomics* (1990). Jeffrey Frankel presents evidence that flows of short-term capital eliminate differences in nominal interest rates among developed countries. See J. Frankel, "Quantifying International Capital Mobility in the 1980s," in B.D. Bernheim and J.B. Shoven, eds., *National Saving and Economic Performance* (Chicago: University of Chicago Press, 1991).

The fact that capital is not moving into developing countries (and, indeed, is moving out of those countries) is probably explained by reasons that have nothing to do with ratios of capital to labor or profit rates. Capital may not flow to developing countries because investors have a greater perceived risk that their funds or property might be expropriated or because they lack information about local markets. Other reasons include the lack of infrastructure or other complementary factors of production in developing countries, an adverse political environment (especially with regard to capital controls in the future), or a lack of institutional relationships. Recent experience in Mexico demonstrates the importance of political factors: capital flowed back into the country when the political climate became friendlier to private investment.

Flows of Labor

The evidence on flows of labor between countries is not strong enough to add much to the evaluation of the models of economic growth. Few analysts would argue with the proposition that large and persistent gaps in per capita income among countries result in constant pressure for workers to migrate from poor countries to rich countries. This phenomenon would seem to favor models of endogenous growth, several of which contain specific mechanisms to generate such differences in income. However, the neoclassical model, augmented to include human capital, would predict that any existing gaps in income would persist for decades.

CONCLUSION

What conclusions can be drawn from the foregoing discussion? First and foremost, it is too early to jettison either the neoclassical framework or its basic conclusions about the effects of government policy. The model's crucial assumptions (for example, decreasing returns to capital) appear to be justified, and the model's predictions (for example, convergence) hold when it controls for differences in steady states among countries. In addition, some of the anomalies associated with the model, such as the slow rate of convergence, can be explained by modifying it to include human capital as a factor of production. But even the augmented model requires exogenous technical change in order to generate growth in per capita output. Despite the advances in growth accounting that have reduced the proportion of growth attributable to technical change, the theory still has an important limitation in that a significant portion of economic growth is assumed to occur exogenously.

The studies of endogenous growth have provided many new ways to think about long-run growth and a more diverse set of mechanisms for analyzing the effects of government policy. The early models of Romer and Lucas were highly simplified, but they have given way to more realistic models that have better empirical support. In fact, it is difficult to make a clear distinction between the neoclassical and the endogenous growth frameworks because the differences between the two are shrinking steadily. Many of the latest models are better viewed as extensions of the neoclassical model than as replacements for it. One interpretation of the new models is that they "endogenize" the technical change that is assumed to occur exogenously in the neoclassical model. The explicit treatment of the economics of innovation found in the models of Romer and of Grossman and Helpman is an important step toward accounting for technical change.

What new policies can be recommended based on these studies? None, really. Nearly all of the studies are performed at a high level of aggregation and are therefore too general to provide specific guidelines for policymakers. But the new models indicate broad areas in which to look for policies that may prove to be effective. The most promising area seems to be investment in human capital, including both schooling and on-the-job training. Lower taxes on investment in physical capital, carefully directed investment spending by the government (perhaps in the form of subsidies for R&D), and increased international trade are other recommendations. But one cannot say that investments in any of these areas will result in extraordinary growth; the results are preliminary.

The findings of this survey provide optimism about the benefits of deficit reduction. The best empirical evidence does not support the prediction that reducing the deficit will permanently boost the rate of economic growth (perhaps because of extraordinary returns associated with investment in physical capital). But it does support the augmented neoclassical model, which predicts that the bang per buck of deficit reduction is larger than in the standard version of the model. The results of the new models sound a cautionary note about deficit reduction, however: they suggest that the manner in which the deficit is reduced does matter. If the models have any validity at all, then policymakers should avoid increasing the relative tax burden on capital.

